School of
Applied Computing

Network Simulation

NetSim
Exercise 10 (Optional)

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10.Experiment on M/D/1 Queue:

-To create an M/D/1 queue: a source to generate packets, a queue to act as the buffer and server, a sink to dispose of serviced packets.

-To study how the queuing delay of such a system varies.

10.1 Theory:

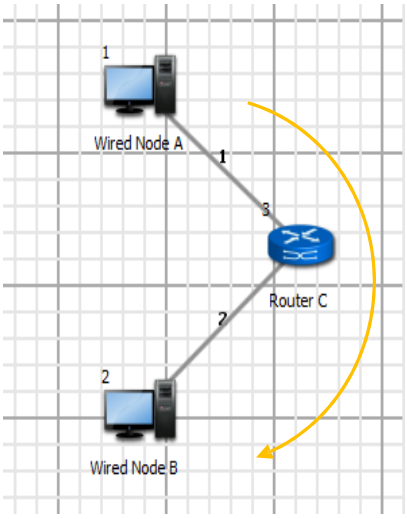
In systems where the service time is a constant, the M/D/1, single-server queue model, can be used. Following Kendall's notation, M/D/1 indicates a system where:

- **Arrivals** are a Poisson process with parameter **λ**
- **Service time(s)** is deterministic or constant
- There is **one server**

For an M/D/1 model, the total expected queuing time is $T = \frac{1}{2\mu} \times \frac{\rho}{1-\rho}$

Where μ = Service Rate = 1/Service time and ρ is the utilization given as follows, $\rho = \frac{\lambda}{\mu}$

To model an M/D/1 system in NetSim, we use the following model



Traffic flow from Node 1 to Node 2 (Node 1: Source, Node 2: Sink)

Inter-arrival time: Exponential Distribution with mean 2000 μs

Packet size: Constant Distribution with mean of 1250 bytes

Note:

1. Exponentially distributed inter-arrivals times give us a Poisson arrival process. Different mean values are chosen as explained in the section Sample Inputs. (Dropping the devices in different order may change the result because the random number generator will get initialized differently)

2. To get constant service times, we use constant distribution for packet sizes. Since, the service (which in our case is link transmission) times are directly proportional to packet size (greater the packet size, greater the time for transmission through a link), a constant packet size leads to a constant service time.

Procedure:

Create Scenario: ‒Simulation → New → Internetworks‖.

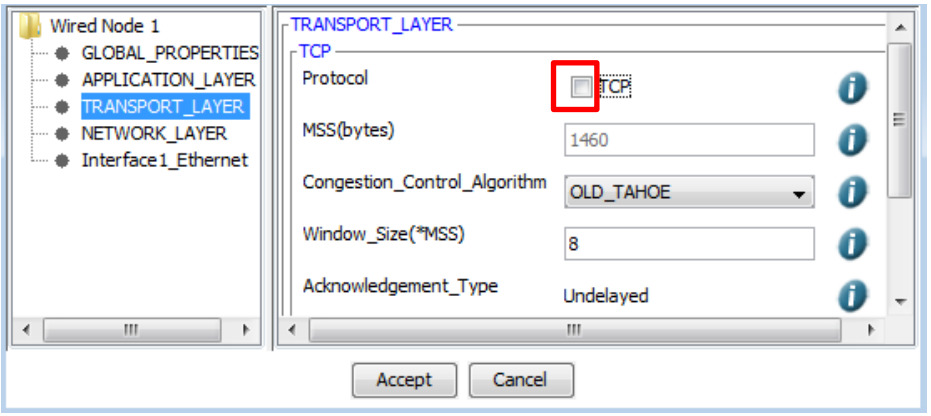
Nodes 1 and Node 2 are connected with Router 1 by Link 1 and Link 2 respectively. Set the properties for each device as given below,

Sample 1:

Application Properties: Click and drop the Application icon and set following properties:

Application Type	Custom	
Source_Id	1	
Destination_Id	2	
Packet Size	**Distribution**	Constant
	Value (bytes)	1250
Inter Arrival Time	**Distribution**	Exponential
	Packet Inter Arrival Time (µs)	2000

Disable TCP in the Transport Layer in **Node Properties** as follows:



Link Properties	Link 1	Link 2
Uplink Speed (Mbps)	10	10
Downlink Speed (Mbps)	10	10
Uplink BER	0	0
Downlink BER	0	0
Uplink Propagation Delay (ms)	0	0
Downlink Propagation Delay (ms)	0	0

Router Properties: Accept the default properties for Router.

Simulation Time: 100 Sec

Observation:

Even though the packet size at the application layer is 1250 bytes, as the packet moves down the layers, some overhead is added which results in a greater packet size. This is the actual payload that is transmitted by the physical layer. The overheads added in different layers are shown in the table:

Layer	Overhead (Bytes)
Transport Layer	8
Network Layer	20

MAC layer	26
Physical Layer	0
Total	54

Therefore, the payload size = Packet Size + Overhead

= 1250 + 54

= **1304 bytes**

Theoretical Calculation:

By formula,

$$Queuing\ Time = T = \frac{1}{2\mu} \times \frac{\rho}{1-\rho}$$

μ = Service Rate, i.e., the time taken to service each packet

= Link capacity (bps) / (Payload Size (Bytes) * 8)

= (10×10^6) / (1304*8)

= **958.59 packets / sec**

λ = Arrival rate, i.e., the rate at which packets arrive (Packets per second)

Inter-arrival time = 2,000 micro sec

Arrival rate λ = 1/ Inter Arrival time

= 1/2000 micro sec

= **500 packets / sec**

ρ = Utilization

= λ/μ

= 500/958.59

= 0.522

By formula, **Queuing Time** = $\frac{1}{2\times958.59} \times \frac{0.522}{1-0.522}$ = **569.61 micro sec**

10.2 Output:

After running the simulation, check the **"Delay"** in the Application Metrics.

Delay = 2656.855 micro sec

This Delay (also known as Mean Delay) is the sum of Queuing Delay, Total Transmission time and Routing Delay.

$$\begin{pmatrix}\textbf{Mean}\\ \textbf{Delay}\end{pmatrix} = \begin{pmatrix}\textbf{Queuing}\\ \textbf{Delay}\end{pmatrix} + \begin{pmatrix}\textbf{Total Transmission}\\ \textbf{Time}\end{pmatrix} + \begin{pmatrix}\textbf{Routing}\\ \textbf{Delay}\end{pmatrix}$$

Total Transmission Time is the sum of transmission time through Link 1 and Link 2.

Transmission time through each link is the same and is given by:

Transmission time through each link = $\dfrac{Payload\ Size\ (Bytes) \times 8}{Uplink\ Speed\ (bps)}$

$$= \frac{1304 \times 8}{10 \times 10^6}$$

= 1043.2 micro sec

Routing Delay is approximately 1 micro sec and can be found from the Event Trace. It is the difference between ‒Physical In‖ and ‒Physical Out‖ time for the Router.

Therefore, for simulation

Queuing Delay = 2656.855– (2 × 1043.2) – 1 = 569.455 micro sec

Sample 2

Keeping all the other parameters same as in previous example, if Packet Inter Arrival Time is taken as 1500 micro sec, then

λ = 666.67 packets per sec

Utilization **ρ = λ/μ = 666.67/958.59 = 0.695**

And **Queuing Time T = 1188.56 micro sec**

From NetSim,

Delay = 3279.297 micro sec

Therefore, **Queuing Time** = 3279.298 - (2×1043.2) – 1

= **1191.898 micro sec**

Note: Obtained value is slightly higher than the theoretical value because of initial delays in forming ARP table, Switch table and Routing table etc.

A Note on M/M/1 queuing in NetSim

M/M/1 queue can be generated similarly by setting the ‗**Packet Size Distribution**‖ as ‗**Exponential**‖ instead of ‗**Constant**‖. However, the results obtained from simulation deviate from the theoretical value because of the effect of packet fragmentation. Whenever a packet with size greater than Transport Layer MSS and / or MAC Layer MTU (which is 1500 bytes in NetSim) is generated, it gets fragmented in the application layer. Then the packet is sent as multiple frames, and makes it impossible to calculate the exact queuing time.